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Technology Organisation
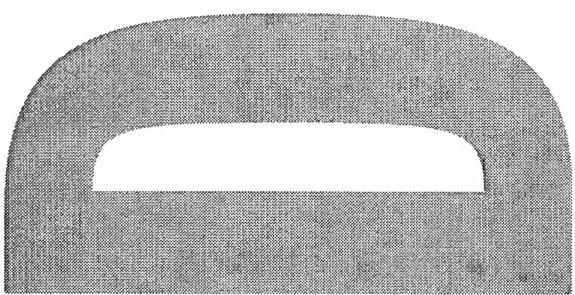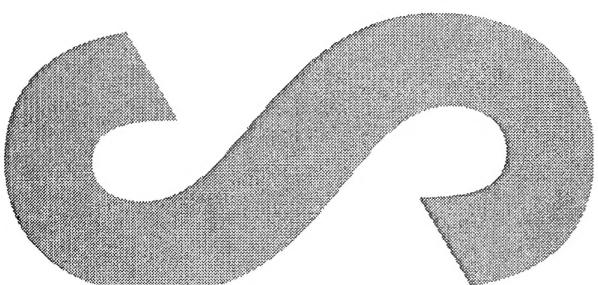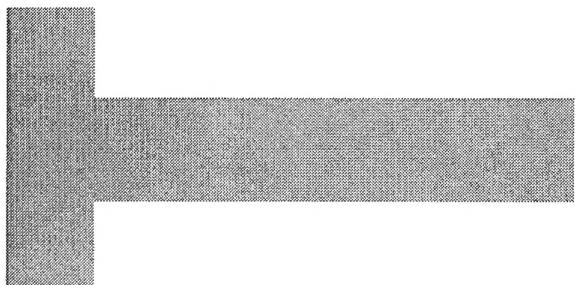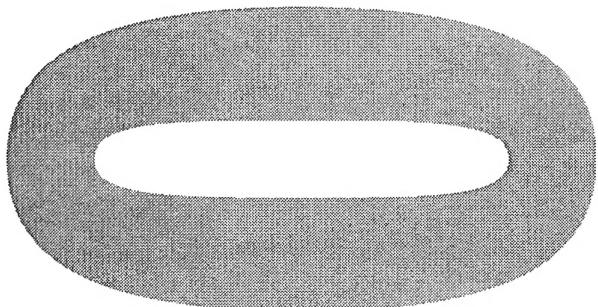
DSPFRC - Force and Moment Data Display and Monitoring Program for the Low Speed Wind Tunnel at DSTO

Stephen Lam and

Adam Blandford

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Air Vehicles Division
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ABSTRACT

DSTO operates a low speed wind tunnel within the Air Vehicles Division of the Platforms Sciences Laboratory. Airspeeds up to approximately 100 m/s can be produced in the empty test section which is 2.7 m wide by 2.1 m high. Realtime display of acquired test data from the wind tunnel is important for providing feedback to the project manager and test engineer. A software package called DSPFRC was developed for this purpose, giving a graphical display of the force and moment coefficients. This document provides details of the software and its operation. It also provides information on programming and development considerations of the software.

RELEASE LIMITATION

Approved for public release

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APPROVED FOR PUBLIC RELEASE

DSPFRC - Force and Moment Data Display and Monitoring Program for the Low Speed Wind Tunnel at DSTO

Executive Summary

Measuring the aerodynamic forces and moments on models of airborne bodies is one of the major functions of the Low Speed Wind Tunnel (LSWT), operated by the Defence Science and Technology Organisation (DSTO). The data acquired by these measurements are needed for the evaluation, design, and research into military aircraft, missiles, and air vehicles in general, and for assessment of their performance.

A software package called DSPFRC has been developed as part of the Data Acquisition System in the LSWT, and it is responsible for displaying and monitoring the force and moment data acquired from the model under test.

DSPFRC has been developed in the Microsoft Visual Basic programming environment to provide the user with graphical displays. This has created a user-friendly environment and enabled faster and easier monitoring of wind tunnel results both qualitatively and quantitatively in near real time. With this interface, any abnormality of the data can be noticed immediately and the test engineer can then decide if the data point needs to be re-acquired or the test sequence altered. Malfunctioning of the test equipment can also cause abnormalities, and they can now be rectified immediately. Real-time display of acquired data is an important tool and an integral part of the data acquisition system for the DSTO wind tunnels, and the software developed could have application to other test cells.

The new software has achieved all its design specifications and has proved to be successful as it provides the test engineer with a means for monitoring test results as the test progresses. It also extends the capability of DSTO to obtain low speed aerodynamic data with improved accuracy and efficiency.

Authors
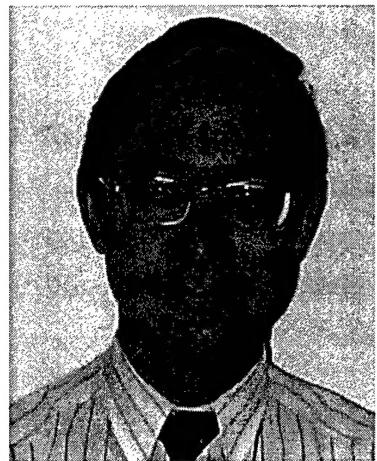
Stephen Lam
Air Vehicles Division

Dr Stephen Lam graduated from University of Melbourne with a Bachelor Degree of Engineering (Mechanical) in 1979, and obtained a degree of Master of Engineering Science in 1982 from the same university. He later undertook a research study at Monash University and was awarded the degree of Doctor of Philosophy in 1990. Stephen joined DSTO in 1988 and has since been working in the area of wind tunnel research. Stephen has worked on a variety of wind tunnel projects in both the Low Speed and Transonic Wind Tunnels. He was appointed as a Senior Research Scientist in 1999, and is currently overseeing all test programs that are being conducted at the DSTO Fishermens Bend Wind Tunnel Facilities.
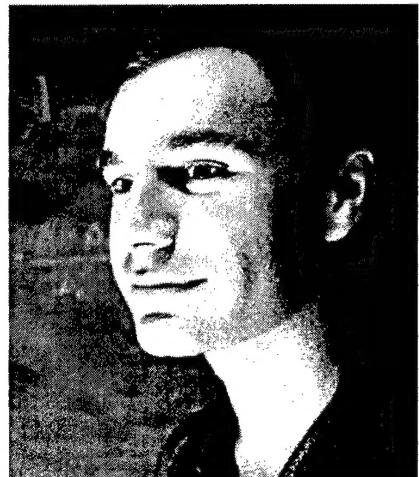
Adam Blandford
Air Vehicles Division

Adam Blandford graduated from the Royal Melbourne Institute of Technology in 2000 completing a Bachelor of Engineering (Aerospace) with First Class Honours. The following year he obtained employment with the Defence Science and Technology Organisation at Melbourne. Working in Flight Systems, he has gained experience in the area of wind tunnels and experimental aerodynamics. Recently he played a major role in the F-111/AGM-142 store clearance project in the Transonic Wind Tunnel, and he has made significant contributions to the JDAM-ER tests in this tunnel. He has also been involved in improvements to the wind tunnel data acquisition systems and the development of test techniques.

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1. Introduction

Wind tunnels are one of the primary sources of aerodynamic data for aeronautical research and support. The Australian Defence Science and Technology Organisation (DSTO), owns and operates a number of major wind tunnels and a water tunnel. The Low Speed Wind Tunnel (LSWT), was designed in 1939 and commissioned in 1941. It operates at atmospheric pressure in the test section and it has a closed-jet, single-return-circuit. The test section is an irregular octagon, 2.74 metre wide, 2.13 metre high, and 6.56 metre long. A single stage 3.96 metre diameter, eight-bladed fan, driven by electric motors with a total power output of 660 kW, provides a wind speed of up to 100 metre/sec in the empty test section at a fan rotational speed of 750 revs/min.

Measuring the aerodynamic forces and moments on models of airborne bodies is one of the major functions of the LSWT at DSTO. The data acquired by these measurements are needed for the evaluation, design, and research of military aircraft, missiles, and air vehicles in general, and for assessment of their performance.

A computerised on-line Data Acquisition System (DAS), was implemented in the LSWT in the early 1970s. The acquired data was then sent to the central site computer for processing via a dedicated line, providing near real-time feedback to the test engineer. Any abnormality of the data was immediately noticeable and the test engineer could then decide if the data point needed to be re-acquired or the test sequence altered. Malfunctioning of the test equipment could also cause an abnormality, in which case it could be rectified immediately. Real-time display of acquired data is an important tool and an integral part of the data acquisition system at the DSTO wind tunnels.

When the PDP-11/44[1] mini-computer was installed at the LSWT in 1982, the real-time data display program, known as DSPFRC (a reduction of 'display force'), used low level and hardware dependent commands to display the data points in graphical form on a DSCAN graphical monitor. With the replacement of the PDP-11/44 by the MicroVAX II[1] computer in 1990, a new DSPFRC program was developed to accomplish the real-time display task. This was developed on an IBM[2] compatible personal computer (PC) under MS-DOS, providing a simpler programming environment.

In the late 1990s the host computer of the LSWT DAS was upgraded to a more powerful DEC AlphaServer 400 running a Digital UNIX operating system. The main DAS software was re-written under the X-Window environment to provide a more user-friendly graphical interface. To access X-Windows on the UNIX system, several PCs running Microsoft Windows are connected to the DEC Alpha computer via a local Ethernet network, and an X display server (x-win32) supplied by Starnet is installed on each of the PCs to provide an X terminal interface.

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[1] PDP and MicroVAX are registered trademarks of the Digital Equipment Corporation.
[2] IBM is a registered trademark of the International Business Machines Corporation.

With the phasing out of MS-DOS, the earlier version of DSPFRC was incompatible with the newer Microsoft Windows operating system. A new version of DSPFRC had to be written for the Ethernet network and Microsoft Windows environment. This document gives details of this new version of DSPFRC, particularly from an operational point of view.

The current version of DSPFRC running in the LSWT is revision 2.1.

2. Function and Features of the Program

The fundamental requirement of DSPFRC is to display and monitor, in real time, the force and moment data acquired by the LSWT data acquisition system in the form of x-y charts. These data are normally supplied by COMFRC[3] in terms of the 6 force and moment coefficients based on:

Either the wind axis system;
- CDw – Drag;
- CCw – Cross-wind;
- CLw – Lift;
- Clw – Rolling moment;
- Cmw – Pitching moment;
- Cnw – Yawing moment.

Or the body axis system;
- CxB – Axial force;
- CyB – Side force;
- CzB – Down force;
- ClB – Rolling moment;
- CmB – Pitching moment; and
- CnB – Yawing moment.

The main DSPFRC window has six separate plots, each plot representing a specific coefficient. These coefficients can be identified by different symbols, and discrete blocks of data are distinguished with different colours. The value of the data block constant for each block of data is shown in the legend key. The data block constant is the parameter that is kept constant within a collection of data points. A seventh plot may also be shown plotting the lift coefficient against the drag coefficient.

Data from pre-existing files, commonly known as history data, can be superimposed onto the same display for comparisons. History data are plotted with lines only, and the history data block constant(s) are given in the legend key.

A typical screen-shot of the DSPFRC primary window is shown in figure 1. Selected data blocks and coefficients may be enlarged and shown on a single plot in a secondary window as shown in figure 2.

If required, hard copy outputs of the graphs in either the primary window, or the secondary window, can be produced on the colour laser printer connected to the LSWT network. Hard copy outputs are sent to the default printer of the PC where DSPFRC resides.

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[3] COMFRC is the main force and moment data acquisition software running on the LSWT DEC Alpha computer.
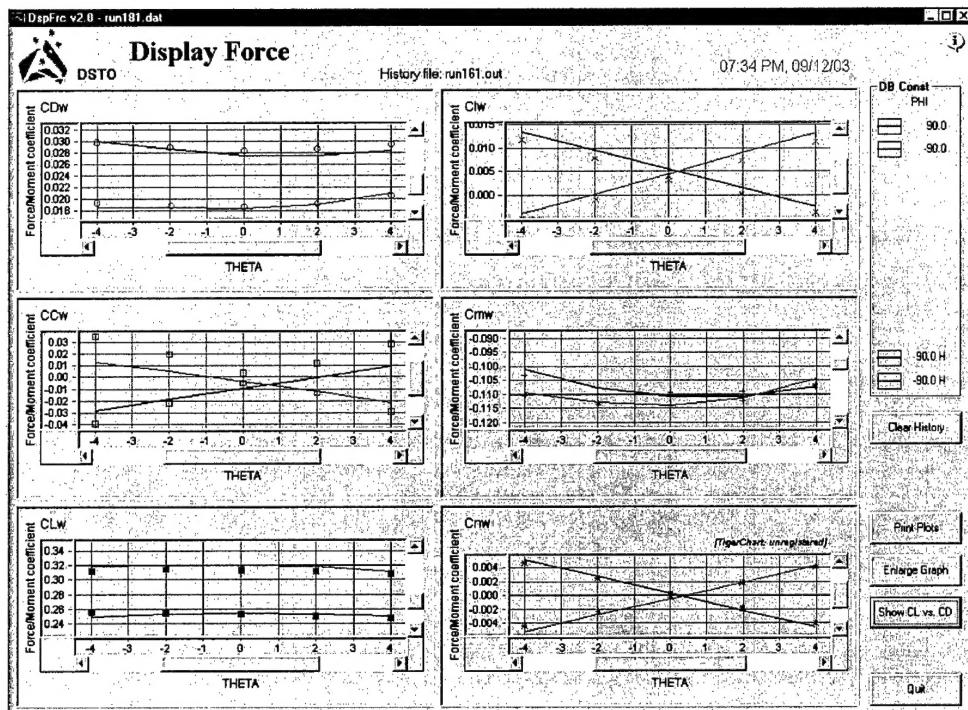
*Figure 1: Screen-shot of the primary window in DSPFRC*
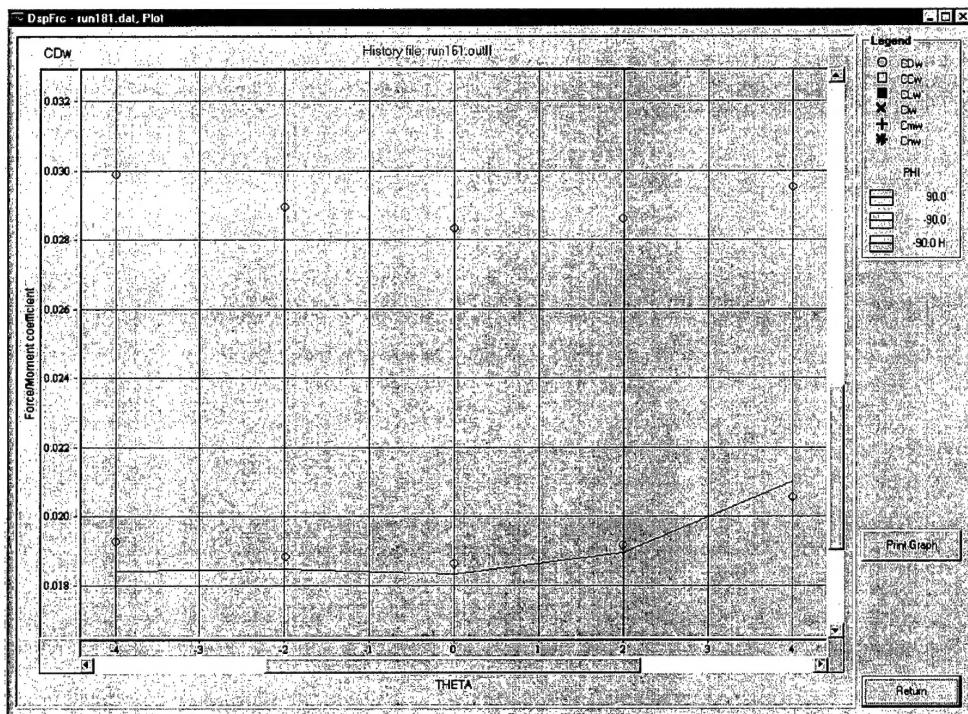
Figure 2: Screen-shot showing a typical example of the DSPFRC secondary window

3. Hardware Configurations

DSPFRC was developed on an IBM-compatible PC running Microsoft Windows 2000 using Microsoft Visual Basic 6, SP5, because of its simple graphical programming environment.

To obtain force and moment data from the LSWT data acquisition system, the IBM-compatible PC communicates with the DEC Alpha using the User Datagram Protocol (UDP) via Ethernet. This communication method is configured in the software (COMFRC and PLTFRC) running on the DEC Alpha. The IP address is set to 192.168.1.169 and the Port address is 4950. If DSPFRC is transferred to another PC, the IP address in the source-files "talker.c" and "display.h" must be changed to the PC on which DSPFRC is to be run. Both COMFRC and PLTFRC must then be recompiled.

The PC that DSPFRC runs on must contain the ActiveX controls **<mswinsck.ocx>**, which are automatically installed with Microsoft Visual Basic, and **<TigerChart.ocx>**, which must be installed on the PC from the setup file in "tiger###.zip". This file is contained in the archive "dspfrc.zip", which is located in the standard LSWT RCS repository (/usr/users/windtun/source/RCS) on the DEC Alpha host computer. COMFRC sends all necessary information required by DSPFRC to display the data on the graphic screen.

The print functions within DSPFRC require a printer to be setup for the PC. This printer may be any type, however, as the plots are in colour it is important for the default printer to be colour.

4. DSPFRC Commands

DSPFRC functions as a *slave* program as it only 'listens' to the DEC Alpha over the Ethernet. It accepts messages sent by programs that run on the DEC Alpha and responds accordingly. Theoretically, DSPFRC will accept any message sent to the IP address of the PC on Port 4950. DSPFRC does not 'talk' to the DEC Alpha under any circumstances. The DSPFRC commands are designed to be as intuitive as possible and are invoked primarily through standard mouse point-and-click operation. Details of their usage are described as follows.

4.1 Commands related to the program functionality

The commands related to the program functionality are controlled by clicking appropriate buttons in the active window:

a) <u>Displaying the program information screen</u> — This screen gives a brief description of the software and states the running version and is activated by clicking the info icon, ⓘ.

b) <u>Viewing a plot of C_L versus C_D</u> — To view a plot of the lift coefficient versus the drag coefficient, the user clicks the "*Show CL vs. CD*" button. To return to the standard six-coefficient plot view, the user clicks the same button, which would now have the caption "*Hide CL vs. CD*".

c) <u>Enlarging a chart with desired coefficients and data block constants</u> — To view an enlarged chart on a secondary window that shows the desired coefficients and data block constants, the user clicks the "*Enlarge Plot*" button. This brings up a selection box, shown in figure 3, with the coefficients and available data blocks as toggle boxes. After selecting the desired coefficients and data block constants by clicking in their appropriate toggle box, the enlarged plot is displayed by clicking on the "*Select*" button.
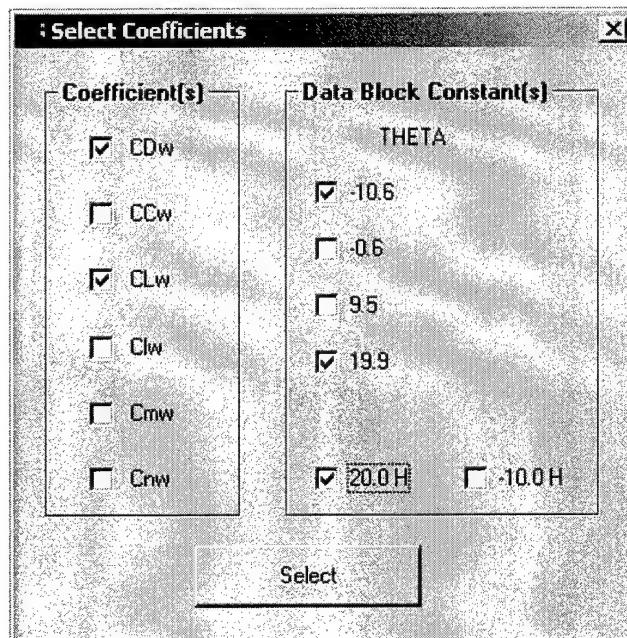

Figure 3: Coefficient and Data Block Constant Selection Box

The *"Return"* button will close the secondary window and return the focus to the primary DSPFRC window. Note that the user may switch back and forth between the primary window and the secondary window by clicking the appropriate tab in the windows toolbar at the bottom of the screen, as long as the secondary window remains open.

d) Clearing the history plot data — If history data has been plotted, it may be removed by clicking the *"Clear History"* button.

e) Printing the active window — Clicking the *"Print Plots"* button in the primary window or the *"Print Graph"* button in the secondary window will print the active window with a white background and timestamp the time printed on the default printer.

f) Closing the program — The program may be closed by clicking either the *"Quit"* button or the standard windows cross in the upper right hand corner of the primary window. Both of these methods will give a prompt, asking the user if they are sure they want to exit the application.

4.2 Commands relating to the chart options

Options for each individual chart are accessed by right clicking in the desired chart. This will bring up a menu as shown in figure 4.
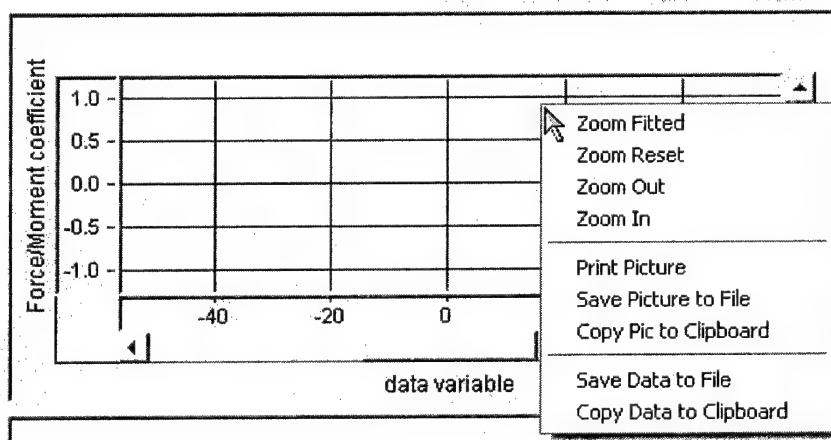

Figure 4: Menu showing the chart options

These options are described as follows:

a) <u>Zoom Fitted</u> — This will automatically scale the x and y axes so that the view area fits around the acquired data.

b) <u>Zoom Reset</u> — Zooms the chart to the global borders (the global borders are the limiting borders that are set within the program).

c) <u>Zoom Out</u> — Zooms out by a factor of 2.

d) <u>Zoom In</u> — Zooms in by a factor of 2.

Zooming can also be performed by dragging one of the corners of the graph, using the left mouse-button, to the desired range.

e) <u>Print Picture</u> — Prints the current chart to the default printer.

f) <u>Save Picture to File</u> — Saves the current view of the chart to a bitmap-file.

g) <u>Copy Pic to Clipboard</u> — Copies the current view of the chart to the clipboard. Use the paste option in the application where the picture is to be inserted.

h) <u>Save Data to File</u> — Saves the data (x/y-values) of all plots on the chart to a file.

i) <u>Copy Data to Clipboard</u> — Copies the current data (x/y-values) to the clipboard. Use the paste option in the application the data is to be inserted (e.g. MS Excel).

5. Plotting History Data (PLTFRC)

Data from pre-existing files on the DEC Alpha may be sent to DSPFRC and plotted on the same displayed graphs as the real-time data for comparisons. This has to be initiated from the data acquisition program, COMFRC, running on the DEC Alpha. History data is plotted by clicking the *"History"* button from within COMFRC. This activates "pltfrc" which prompts the user to choose the history data file from a file selection dialogue box, shown in figure 5.
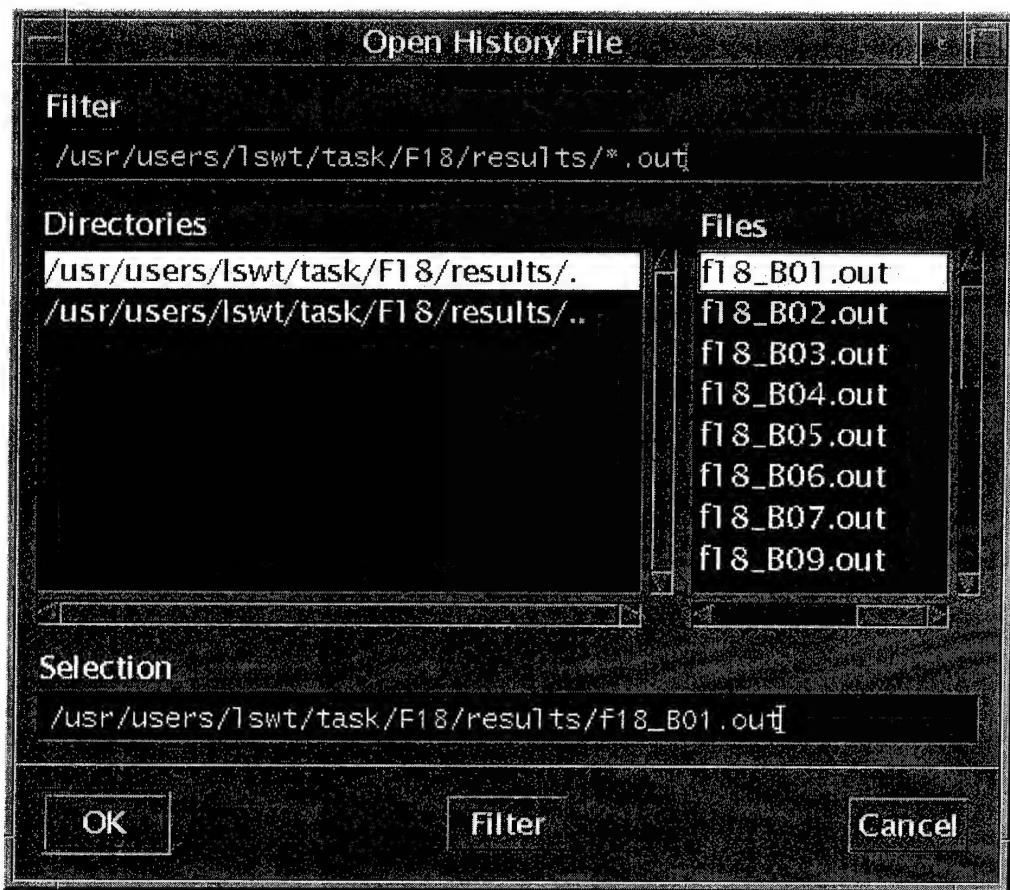
Figure 5: History data file selection dialogue box

After selecting a file, the appropriate axes, body or wind, must be chosen by clicking on the appropriate radio button in the selection box, as shown in figure 6.
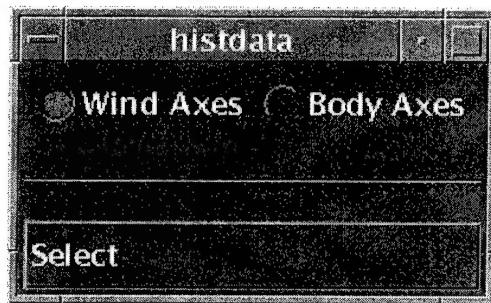

Figure 6: Axes selection box

PLTFRC then reads this data file, extracts the appropriate data and sends the data over the network in the format necessary for DSPFRC. On receipt of history data, DSPFRC brings up a selection box prompting the user to select the desired data blocks from the history file. A maximum of two history blocks may be chosen. If more blocks of history data are required it is necessary to resend the history file from within COMFRC, and then choose alternate history data blocks to be plotted. It is important that the data block constant parameter, and the data block variable parameter of the on-line run are included in the output file (the history file that is selected). The user should ensure that the history data block constant parameter and data block variable parameter match those being used in the online test for meaningful comparisons. If either of these criterion are not satisfied, PLTFRC will send an appropriate error message over the network which DSPFRC will read and convey the error to the operator through a message box.

For the sake of clarity all history data are plotted with lines only, while the real time data points are denoted by symbols. Different blocks of history data are plotted with different line colours. The legend key denotes history data by a "H" in front of the value of the history data block constant.

6. Programming Considerations of the DEC Alpha

DSPFRC acts as a listener to the DEC Alpha and responds to information sent to the IP address of the PC on port 4950 via Ethernet. The information passed to the PC by the DEC Alpha must, therefore, have a defined format in order that DSPFRC can respond correctly. There are normally two groups of data being sent to DSPFRC — those calculated by COMFRC in real time and those extracted from pre-existing files. All these strings that are received by DSPFRC are logged to a file labelled "udplog.txt". This file is located in the directory that DSPFRC resides and is overwritten each time DSPFRC starts.

6.1 Data sent by COMFRC

Before data is sent to DSPFRC, some information needs to be provided to DSPFRC for proper initialisation. Information such as the name of the data file, the name of the data block constant, and the name of the data block variable are included in this initial message. The command character 'I' is sent indicating to DSPFRC to initialise the plots, followed by the filename. 'C' indicates that the datablock constant parameter follows. 'V' indicates that the datablock variable follows. 'L' is followed by the labels of the six coefficients. A typical initialisation message looks like:

```
I  fa18-01
C  BETA
V  ALPHA
L  CDw CCw CLw Clw Cmw Cnw
```

where `fa18-01` is the name of the data file used for the title of the display, `BETA` is the data block constant used for the legend key, `ALPHA` is the data block variable which is the x-variable, and the last line contains the names of the six coefficients to be used as the y-variables. Thus, it is possible that DSPFRC can be used to display data other than force and moment coefficients simply by including the appropriate names for the x and y-variables in the initialisation message.

In the real time display mode, after COMFRC finishes estimating the six coefficients from the freshly acquired data, it writes the value of the data block constant, that of the data block variable, and those of the six coefficients in one single line headed by the command character 'D' signifying that this is a data line. A typical data line looks like:

```
D 2.06 15.03 0.2536 0.1123 -0.4376 0.0012 -0.1006 -0.0119
```

which means, in the context of the above initialisation message, that

```
BETA   =   2.06,
ALPHA  =   15.03,
CDw    =   0.2536,
CCw    =   0.1123,
CLw    =   -0.4376,
Clw    =   0.0012,
Cmw    =   -0.1006, and
Cnw    =   -0.0119.
```

Apart from the 'I', 'C', 'V', 'L', and 'D' command characters, DSPFRC also responds to the command characters 'B' and 'R' which appear on their own without any attached information. The 'B' command character signifies the beginning of a new block of data. On receiving this, DSPFRC changes the symbol used to plot the data and creates a new legend key for the new block of data. The 'R' command character is sent when the user 'Rejects' a data point. The most recently acquired data will then be deleted from the display.

6.2 Data from pre-existing files

For the purpose of comparisons, data from pre-existing files are often required to be plotted on the same display as the real time data. These are referred to as *history data plots*. Data that are sent to DSPFRC for this purpose are treated differently from the real time data so that they can be distinguished from each other. History data are preceded by several lines of information similar to the initialisation messages in section 6.1. The first line of information contains the word "History" followed in the next line by the name of the file from which data are extracted. This is then followed by the name of the data block constant and the name of the data block variable in separate lines.

History data files may contain several blocks of data and each one will have a different value for the data block constant. Each block of history data sent to DSPFRC must be preceded by the line:

```
\Block
```

and this will be followed by the value of the data block constant on the next line. Lines of history data then follow, which are formatted in the same way as in section 6.1, except the character 'D' is omitted from the beginning of the line. Since history data are extracted from pre-existing files, DSPFRC expects that lines of history data will arrive continuously until the host signals an end condition which is indicated by the line

```
\End
```

The program PLTFRC implements these history-plotting functions automatically, by writing the data in the format described over the Ethernet to the appropriate IP address. It is installed in the directory /usr/users/lswt/bin of the LSWT DEC Alpha computer.

Appendix A shows an example of a set of history data sent to DSPFRC.

Further technical information on programming aspects of DSPFRC and PLTFRC may be found in the following articles on the DSTO Intranet:

"Notes on the DspFrc software",
< http://bernoulli.dsto.defence.gov.au/data_acq/Software/ProgramNotes/DspFrc/>

"Notes on the PltFrc software",
< http://bernoulli.dsto.defence.gov.au/data_acq/Software/ProgramNotes/PltFrc/>

7. Conclusions and Future Development

A software package called DSPFRC has been developed under a new programming environment as part of the Low Speed Wind Tunnel (LSWT), Data Acquisition System (DAS). This was required due to the improvements in the operating system and communication protocols used in the DAS upgrade.

The software displays and monitors, in near real time, the 6 force and moment coefficients calculated in the main DAS software, COMFRC. It also has the ability to overlay history data from previous runs. This document details the operation and functionality of the DSPFRC software, with some emphasis on application by the tunnel engineers and operators.

The software has been developed in Microsoft Visual Basic and a competent programmer, having become familiar with the program, should be capable of making modifications and upgrades if required.

8. References

1. Edwards, C., Lam, S., Link, Y., *COMFRC: Data Acquisition Software for the AMRL Low Speed Wind Tunnel*, DSTO-TN-0347, AR-011-829, DSTO Aeronautical and Maritime Research Laboratory, Australia, April 2001.

2. Holland, O., Lam, S., Link, Y., *A New Data Acquisition System for the AMRL Low Speed Wind Tunnel*, DSTO-TR-0896, AR-011-129, DSTO Aeronautical and Maritime Research Laboratory, Australia, November 1999.

Appendix A: AN EXAMPLE OF HISTORY DATA FORMAT

```
History
P04-1
BETA
ALPHA
\BLOCK
    -8.020
 -20.1000    0.0875    0.0018   -0.6318   -0.0033    0.6368   -0.0005
 -15.0000    0.0770   -0.0016   -0.6094   -0.0035    0.5573   -0.0005
  -9.9000    0.0677   -0.0017   -0.5819   -0.0033    0.4702   -0.0005
  -4.9000    0.0597   -0.0014   -0.5515   -0.0033    0.3708   -0.0003
   0.0000    0.0531   -0.0012   -0.5175   -0.0036    0.2609   -0.0005
   5.0000    0.0489   -0.0006   -0.4781   -0.0032    0.1394   -0.0004
  10.1000    0.0463   -0.0016   -0.4406   -0.0030    0.0110   -0.0005
  15.0000    0.0459   -0.0005   -0.4004   -0.0032   -0.1006   -0.0004
  20.0000    0.0502   -0.0015   -0.3724   -0.0030   -0.1917   -0.0009
\BLOCK
    -4.017
 -20.1000    0.0628   -0.0008   -0.2855   -0.0030    0.5326   -0.0010
 -15.0000    0.0543   -0.0007   -0.2626   -0.0029    0.4584   -0.0010
  -9.9000    0.0463   -0.0006   -0.2385   -0.0026    0.3797   -0.0010
  -4.9000    0.0402    0.0002   -0.2083   -0.0029    0.2850   -0.0008
   0.0000    0.0360   -0.0001   -0.1736   -0.0027    0.1699   -0.0007
   5.0000    0.0341    0.0005   -0.1362   -0.0029    0.0481   -0.0007
  10.1000    0.0336    0.0010   -0.0956   -0.0027   -0.0729   -0.0006
  14.9000    0.0375    0.0019   -0.0627   -0.0024   -0.1761   -0.0003
  20.0000    0.0431    0.0016   -0.0356   -0.0029   -0.2598   -0.0007
\BLOCK
     0.002
 -20.0000    0.0512   -0.0008    0.0719   -0.0033    0.4414   -0.0008
 -15.0000    0.0446   -0.0002    0.0958   -0.0031    0.3707   -0.0008
  -9.9000    0.0377    0.0002    0.1126   -0.0029    0.3008   -0.0008
  -4.9000    0.0342    0.0008    0.1444   -0.0032    0.2055   -0.0005
   0.0000    0.0326    0.0017    0.1838   -0.0030    0.0916   -0.0004
   5.0000    0.0329    0.0013    0.2234   -0.0028   -0.0274   -0.0004
  10.1000    0.0351    0.0014    0.2575   -0.0029   -0.1402   -0.0005
  15.0000    0.0396    0.0019    0.2895   -0.0027   -0.2463   -0.0003
  20.0000    0.0471    0.0011    0.3166   -0.0030   -0.3199   -0.0005
\END
```

DSPFRC - Force and Moment Data Display and Monitoring Program for the Low Speed Wind Tunnel at DSTO

Stephen Lam and Adam Blandford

AUSTRALIA

DEFENCE ORGANISATION

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Scientific Adviser Joint	1
Navy Scientific Adviser	Doc Data Sht & Dist List
Scientific Adviser - Army	Doc Data Sht & Dist List
Air Force Scientific Adviser	1
Scientific Adviser to the DMO M&A	Doc Data Sht & Dist List
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Head Flight Mechanics Technology, Neil Matheson	2
Author, Adam Blandford	3

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19. ABSTRACT

DSTO operates a low speed wind tunnel within the Air Vehicles Division of the Platforms Sciences Laboratory. Airspeeds up to approximately 100 m/s can be produced in the empty test section which is 2.7 m wide by 2.1 m high. Realtime display of acquired test data from the wind tunnel is important for providing feedback to the project manager and test engineer. A software package called DSPFRC was developed for this purpose, giving a graphical display of the force and moment coefficients. This document provides details of the software and its operation. It also provides information on programming and development considerations of the software.